
Space Weather Technical Forecast

Issued on Sunday, 16 July 2023 at 01:27 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

Space Weather Forecast Headline: Minor/Moderate R1/R2 Blackouts likely throughout G1-G2/Moderate Likely Storms Day 2 (17 July), and possible Day 3 (18 Jul).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate, with several M-class flares. The largest was a short-duration M2.9 flare observed at 15/0741 UTC from AR3363 (in the southwest quadrant), with an M2.2 also observed at 15/1010UTC from AR3372 (in the northeast quadrant). These two regions are the most notable on the disc, both large but with small delta spots. AR3363 is a mature region, but showing some ongoing development of small surrounding spots and increased activity in the last 24 hours. AR3372 has shown some signs of decay, but remains a wide, but open region with a complex trailer. AR3373 is also of note, with ongoing development of small intermediate spots.

A CME was observed leaving the Sun from the M2.9 flare of AR3363, however this has been preliminary assessed as likely missing, passing ahead of Earth. A couple of other CMEs were observed well-off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Solar winds, observed by ACE and DSCOVR at L1, indicated the tail end of a weak CME magnetic cloud, and transition into the weak high speed stream of CH23. The speed declined from 400km/s to 350 km/s, before jumping back to 400-450km/s after 15/1010 UTC. Density was initially average, but fell below average after 15/1010 UTC. The total magnetic field (IMF), Bt, was initially moderate at 13nT, but gradually eased to be weak at below 7nT from 15/1250 UTC. The north-south component was largely weak and initially northward directed, with maximum 7nT, except between 15/0840-1020UTC when it became southward directed with minimum -7nT, and becoming weak and variable at the end of the period. Phi angle was negative (Towards the sun). Geomagnetic activity was Quiet Unsettled (Kp1-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as observed by GOES16, has been at background levels until 15/1200 UTC, then very slightly rose, before a more visible rise occurred 16/2050 UTC to peak 1.2 pfu at 15/2100 UTC. High energy electron flux (greater than 2MeV) was at background levels. The 24-hour integrated fluence was below the Active (1e8 integrated pfu) threshold on a decreasing trend. A fluence of 1.17e6 pfu was recorded at 16/0000 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Activity is expected to be Moderate, with occasional M-class flares and a slight chance of X-class flares. These most likely from AR3372 and AR3363.

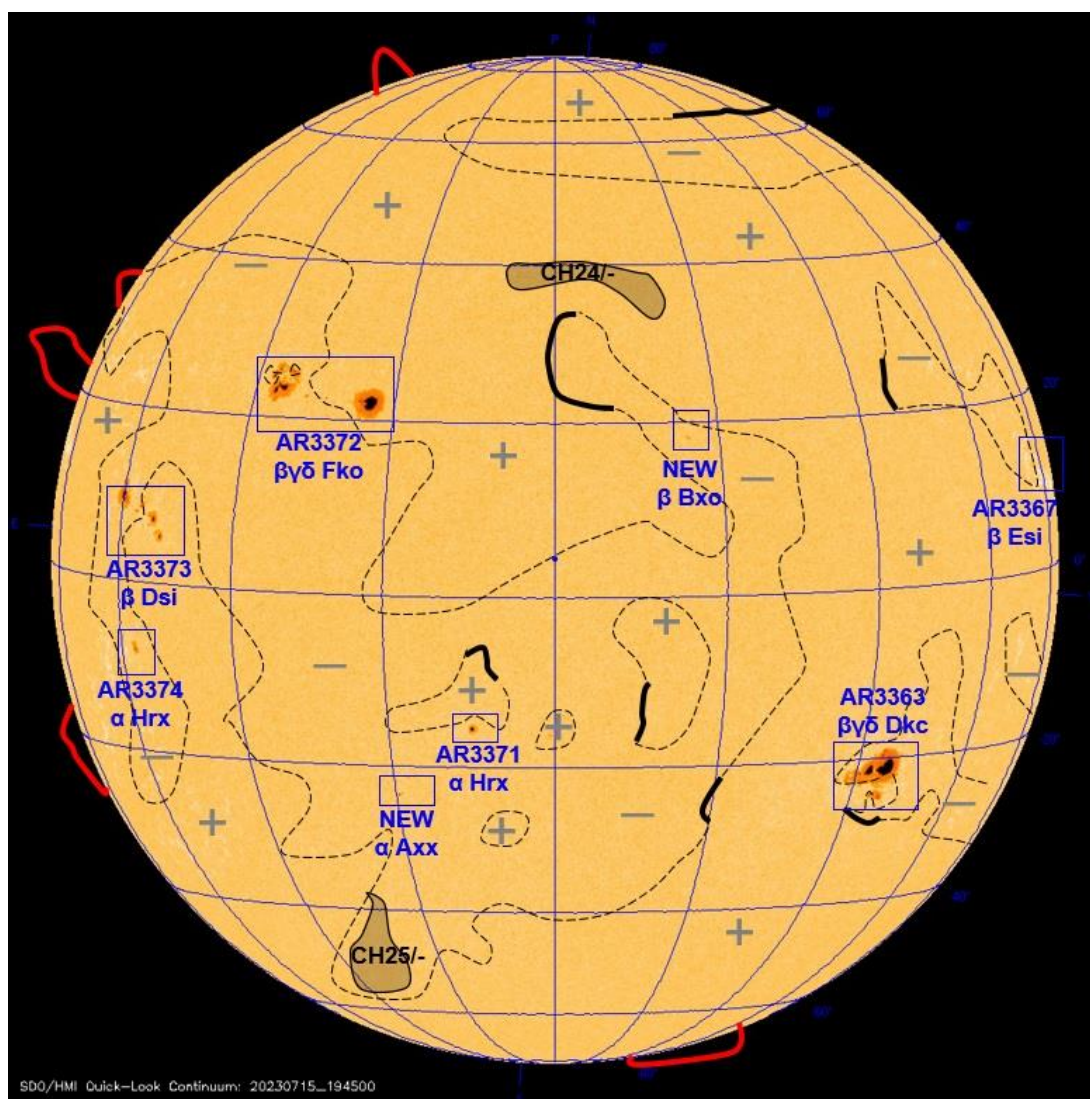
Solar Wind / Geomagnetic Activity: Earth is likely to see a CME arrive on day 2 (17 Jul) from the combined C8.8 flare and filament eruption on the 14 Jul. The strength of any impact is low confidence, due to uncertainties about the material content of any CME, along with limited imagery for analysis, however this is currently expected to arrive 17/1400 +/- 10 hours. Otherwise solar winds are likely to ease towards background day 1 (16 Jul), and again once any CME influence subsides later day 3 (18 Jul). There is a slight chance of a small enhancement from the HSS of CH25 later day 4 (19 Jul). Mainly Quiet geomagnetic activity is expected to

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become Active to G2 Moderate storm during the second half of day 2 (17 Jul). These conditions gradually easing day 3 (18 Jul) to be mainly Quiet by day 4 (18 Jul). There is a slight chance of activity rising again to Unsettled to Active with any CH HSS enhancement from CH24.

Energetic Particles / Solar Radiation: The high energy (greater than 10MeV) proton flux has a slight chance of reaching the S1/Minor Storm threshold through the period, should any larger flares occur. An increase in observed flux may also occur just ahead of the CME arrival expected on day 2 (17 Jul). High energy electron flux (greater than 2MeV) is expected to be at mostly background, perhaps briefly Moderate however fluence is most likely to remain below the Active ($1e8$ integrated pfu) threshold throughout.

Figure 1. Solar Analysis Valid 15/2000 UTC.



Key: Filament —, Prominence —, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α - β - $\beta\gamma$ - $\beta\gamma\delta$ and Zurich-McIntosh Axx etc.

Geomagnetic Storms:

There is one Earth-directed CME in the forecast, however confidence is low regarding the bulk material content of the CME. This left the Sun on 14 Jul from a combination C8.8 flare of AR3370 and associated filament lift, that latter of which is clearly visible as dark plasma moving east across SDO aia-304. A complex and faint CME signature in SOHO imagery followed however available imagery is currently very limited, with other not Earth-directed CME events also obscuring the visibility. Overall, a CME arrival is anticipated to arrive on day 2 at around 17/1400 +/- 10 hours, however the strength of any arrival is very low confidence. This is slightly delayed compared to MOSWOC enlil due to the uncertainty in the analysis.

Otherwise slightly elevated solar winds at first are expected to ease to background day 1 (16 Jul), and then any CME influence is expected to ease through day 3 (18 Jul) with solar winds falling to background by day 4 (19 Jul). There is a chance of a slight increase in solar winds later on day 4 (19 Jul) from CH24 HSS, however only a limited enhancement is currently expected

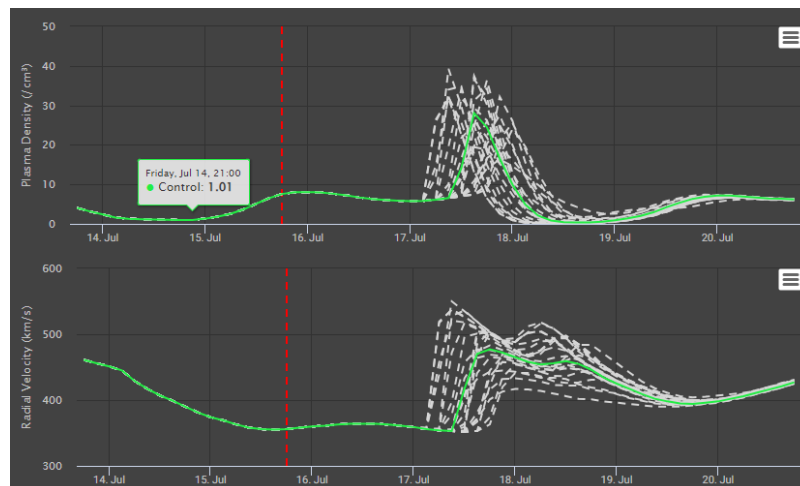
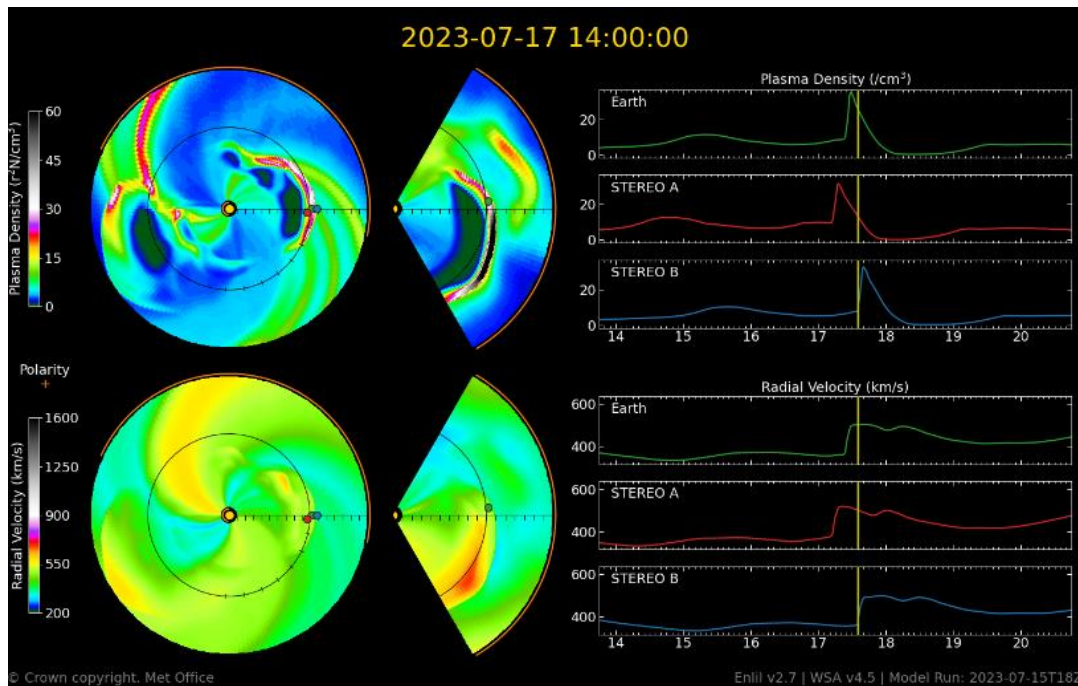
Mainly Quiet geomagnetic activity is expected to become Active to G2 Moderate storm during the second half of day 2 (17 Jul), with a slight chance of G3 Strong Storms. These conditions gradually easing day 3 (18 Jul) to be mainly Quiet by day 4 (18 Jul). There is a slight chance of activity rising again to Unsettled to Active with any CH HSS enhancement from CH24.

Geo-Magnetic Storm	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Minor or Moderate	G1 to G2	No	1	60	40	5
Strong	G3	No	1	20	10	1
Severe	G4	No	1	2	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
14/2155	Asymmetric full	C8.8 flare of AR3370 and filament eruption	S centre disc	832 km/s	17/1400 UTC	Low confidence on strength of impact. Limited imagery for analysis.

Figure 2: Enlil and ensemble showing CME. Arrival forecast slightly delayed compared to enlil.



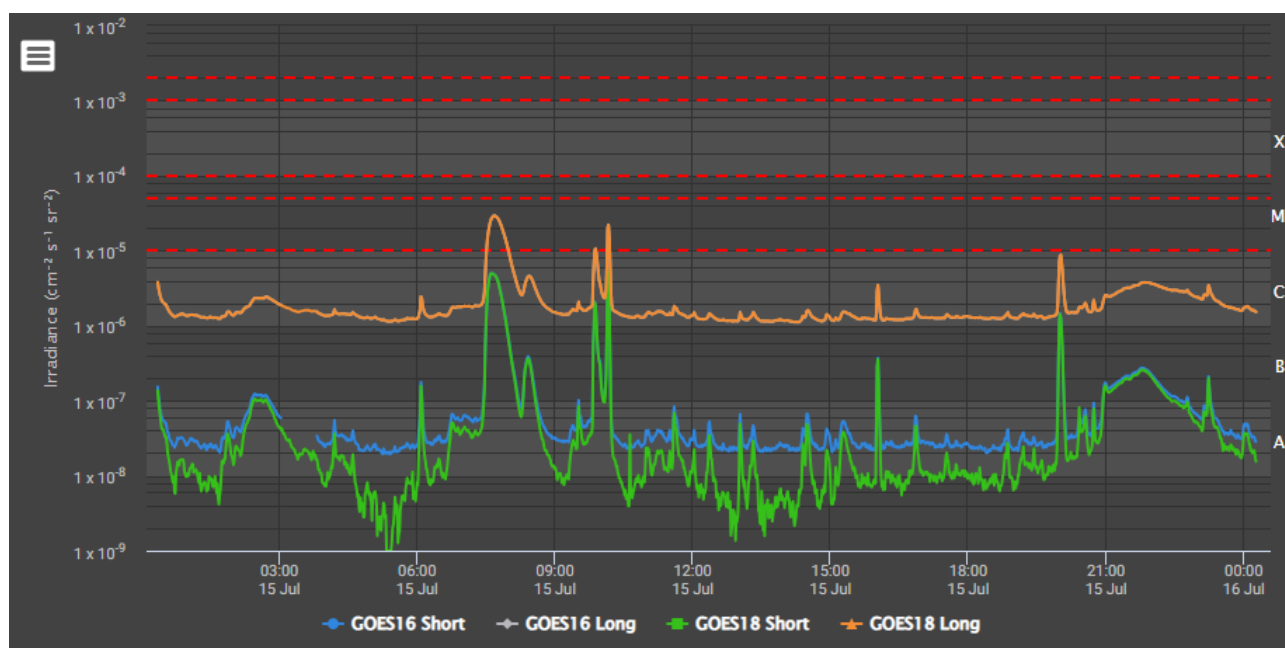
Radio Blackouts - X-Ray Flares:

Solar activity has been Moderate, with several M-class flares. The largest was a short-duration M2.9 flare observed at 15/0741 UTC from AR3363 (in the southwest quadrant) but an M2.2 was also observed at 15/1010UTC from AR3372 (in the northeast quadrant).

There are six numbered sunspot regions visible, and two small new regions. The most notable are both large regions with small delta spots. AR3363 is a mature compact region in the southwest disc, dominated by a large negative umbra, but with small positive spots, including a mixed polarity penumbra region to its south that re-emerged in the last 24 hours. Conversely AR3372 on the northeast disc is a longitudinally wide but open region, with a broadly simple bipolar structure, however this is complicated by a small delta spot near its trailer, leading to some complexity. AR3373, also in the northwest is also of with ongoing emergence of small intermediate spots as it rotates into a clearer view.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	60	60
Very Active	R3 to R5 X Class	No	10	10	10	10

Figure 3: GOES-16 X-ray flux





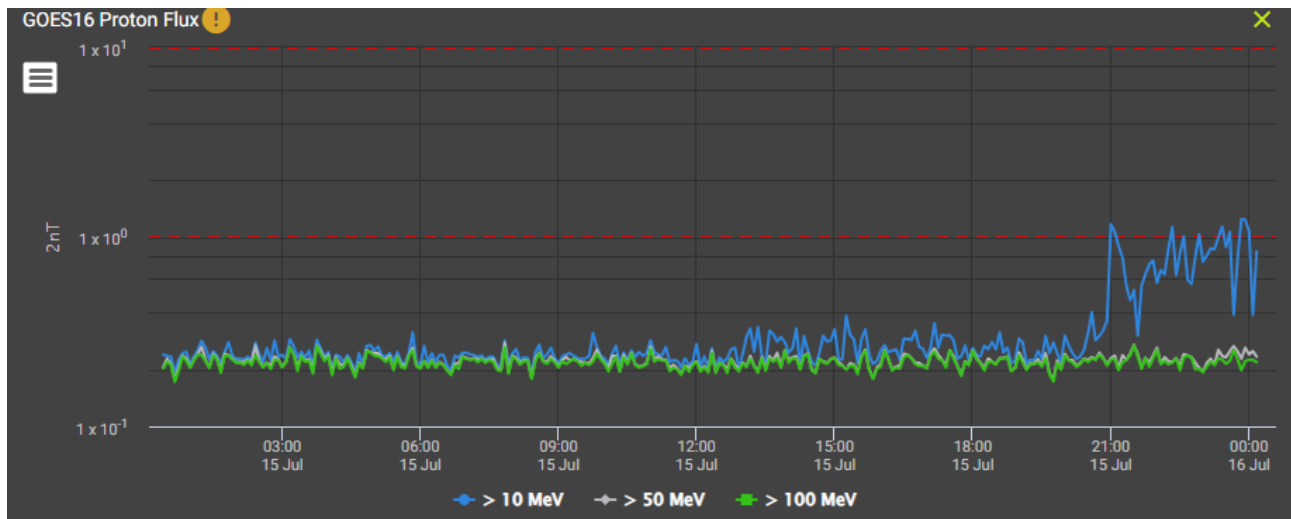
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16, has risen slightly above background, however this remains well below the S1/Minor Storm level. This rise was likely in response to far-sided events, with CMEs observed from over the western limb, or potentially due to the M2.9 flare of AR3363 at 15/0741. Ongoing slight increase in proton flux is possible, however this is unlikely to reach the S1 threshold without further significant flare events occurring. However, the arrival of any CME on day 2 (16 Jul), may collect up protons ahead of it, resulting in a brief increase before flux then decreases again once it passes. This brings a slight chance of reaching the S1 threshold.

Radiation Storms	Level (cm ⁻² sr ⁻¹ s ⁻¹)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ S1	No	15	20	10	10
Very Active	≥ S3 *	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm⁻²sr⁻¹s⁻¹)

Figure 4: GOES-16 Proton Flux



High Energy Electrons Event ($\geq 2\text{MeV}$):

High energy electron flux (greater than 2MeV) at GEO has been at mostly background levels. Background flux, perhaps rising to Moderate briefly on day 1 and perhaps early day 2 (16 and 17 Jul), is expected to persist until at least later on day 3 or day 4 (18 or 19 Jul), as any CME influences arriving on day 2 decline.

The associated 24-hour fluence is expected to remain below the Active ($1\text{e}8$ integrated pfu) threshold, with REFM giving a reasonable guide, although it won't be taking account of any CME arrivals. It is expected that fluence will remain below Active levels throughout.

GEO Electron Environment	Level ($\text{cm}^{-2}\text{sr}^{-1}\text{day}^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^8$	No	1	1	5	10
Very Active	$\geq 2\text{ MeV}$ $\geq 1\text{x}10^9$	No	1	1	1	1